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Abstract:
Mammals must stabilize the head during running to keep angular accelerations of head within the operating range of the vestibulo-ocular (VOR) reflexes. However, several unique aspects of the human body plan and locomotor kinematics make head stabilization more challenging than in other cursors. Most bipedal and quadrupedal cursors have cantilevered heads and necks that act to attenuate forces and counter sagittal head pitching through controlled flexion and extension movements. In contrast, humans have short vertical necks that emerge from near center of head, combined with relatively extended, stiff legs at heel strike (HS), resulting in a strong tendency for the head to pitch forward at the beginning of stance. Using EMG, kinematic, and kinetic measurements of human arm and head movements during running and walking we show that humans stabilize the head following HS using a unique tuned-mass damper system. This mechanism, which links the head with inertial forces in the stance side (ipsilateral) arm, is facilitated by a number of derived aspects of human anatomy and running kinematics. Notably, humans have lost all muscular connections between shoulder girdle and head except for the cleidocranial portion of the trapezius (CCT), which reaches the occiput via a tendon-like nuchal ligament. Additionally, coordinated movements of the arm and thorax position the ipsilateral arm behind the head-neck joint prior to HS, when the ipsilateral CCT fires. Out of phase accelerations of the arm and head then link the counterbalancing mass of the arm and the flexed forearm via a compliant connection to the head, controlling the head's rate of pitch. Because the nuchal ligament, a key component of the system, leaves a trace on the skull, it is possible to show that this novel mechanism for head stabilization originated within the genus Homo approximately 2 millions years ago.